Tug Assist Developments; the need for solutions for tugs operating in waves

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The tug industry is busy and changing rapidly and good order books are being filled with interesting and innovative designs. Many developments are being driven by the end-users of the tug services. Important required services such as the standard harbour assist services are being challenged by the increasing size of container fleets (dimensions and numbers), the high safety demands for LNG carriers and last but not least offshore offloading activities.

The first issue concerns larger vessels as they challenge existing port infrastructures (apart from the capacity issue) and require large, high speed sailing tugs (due to the high 'dead slow' speed of the large vessels which often have to leave the sheltered port to make a timely connection.

The second issue, to do with LNG services, also requires high speed assistance, needed quickly and efficiently and often combined with an escorting assist type of operation in case of an emergency. The offshore offloading services makes it necessary to stay out at sea, assist for longer periods (approach and staying berthed) and again operate in open sea with exposed conditions.

Many of the above aspects come together in Marin's larger than ever Joint Industry Project (JIP) SAFETUG (30 participants) on the operation of tugs in waves. The project addresses both the escorting (high speed) type of assist as well as the berthing (low speed) assist in open, exposed waters, including issues such as fendering, winches and ultimate safety behaviour. The content of the JIP could be summarised as follows:

SAFETUG JIP

Objective

- To identify the relevant modes of tug-terminal operation in various operational contexts

Figure 1. ASD tug tested in waves on thruster degradation.

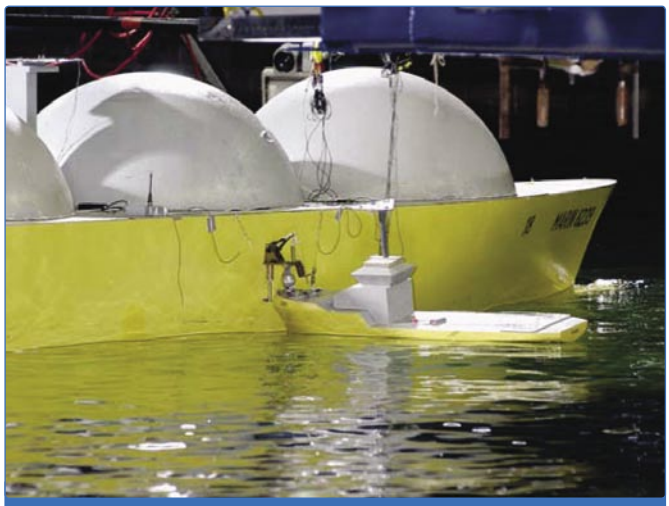

Figure 2. Tug pushing while assisting an LNG carrier.

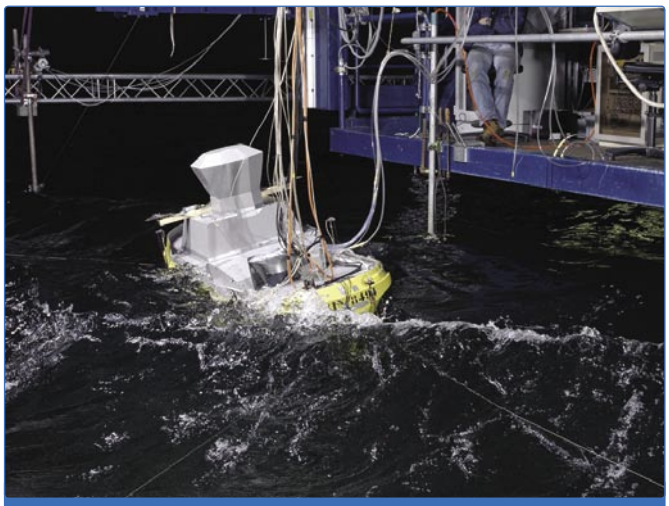

Figure 3. Voith Water Tarctor tested in waves.

- To quantify the appropriate operability envelopes while assisting in waves
- To quantify the operational effectiveness in waves
- To identify the relevant criteria per type of the operation
- To find the important factors in design, equipment and operation

The commitment of all parties involved in the tug-terminal operations is seen as essential for the success of this JIP. The integration of the various technologies and practical experience combined with the envisaged knowledge extension in this JIP, the issues of tugs operating in waves around terminals, can be taken forward. To enable this, the project is currently organised around a design and operations working group.

Deliverables

1. Framework of tug-terminal operations in the various working contexts.
2. Knowledge on: Capability, safety, agility and workability of tug operation.
   Relevant tug design and critical operation parameters.
3. Sets of generic data per two tug types on:
   a. Tow (line/fender) forces in waves (function of .....)
   b. Tug motions in waves (function of .....)
   c. Propulsion degradation in waves (function of .....)
4. A tug performance database.
5. Conclusions on effects/implications on tug/terminal design and operations.

With the JIP now almost completed, the first results start to appear on the two initially chosen current tug designs (ASD and Water Tractor). Both the escorting and the berthing modes were tested in the model basins of Marin in the various type of operations and circumstances.

Initial berthing results

Experience with tugs assisting crude carriers during lightering operations has shown that waves may hamper these tug operations significantly:

- In the pull mode the motions of the tugs in the waves can cause extreme line loads, resulting in breaking of the towline (or even the danger of capsizing of the tug when large loads are applied transverse to the tug).
- In the push mode the motions of the tugs in the waves can induce high impact loads in the fender, resulting in large stresses in the side shell of the LNG carrier.
- Green water on the deck can affect the stability of the tug as well as the safety of the crew.
- Excessive motions can influence the capabilities of the crew that is working on the tug.
- Tugs may need a significant part of their power to stay on station themselves.
- Large tug motions and (relative) wave motions can result in thruster ventilation and reduced thruster efficiency.

From the results it can be concluded that the motions of tugs in waves can be significant, even in wave conditions that are considered to be mild for the berthing and offloading LNG carriers that are assisted by these tugs. The resulting push (see Figure 2) or pull loads may hamper these tug operations significantly:

- Slack tow lines and peak loads occur often, especially when the pull tug is in unshielded conditions. A maximum towload of 1,870 kN is found in the unshielded Hs of 1.9m.
- For the push mode the fender loads are high as well. In the Hs=1.9m condition the maximum fender load at the LNG carrier hull is 1,820 kN when the tug is on the unshielded wave side of the LNG carrier. Compared to the bollard pull of 500kN this is a dynamic amplification of almost four times. This can be critical for the hull of the LNG carrier. Special measures are necessary for the tug fender design and LNG side construction to account for this type of loads over a large area of the side shell.

Initial escorting studies

As part of the systematic test programme the first set of model tests covered the determination of the propulsion efficiency in waves both for the Azimuth stern drives as well as for the Voith Water Tractor units. With various wave heights/lengths and directions, measurements were made at zero and non-zero speed on the net thrust forces available in waves. This turned out to be a valuable exercise which enables us in the following stages to identify the tug assist performance as a function of the wave conditions and subtract the deteriorating effects of the thrusters itself.

The follow on testing programme covered the full set of assist conditions in waves while escorting. Extensive measurements were done on tug motions, heel angle, towline forces (and their variations) and video observations on the safety of the operations (see Figure 3). Apart from a massive amount of data on the performance capabilities in waves, the limits of safe operations, which were decided both on expert

observations as well as on motion and deck wetness criteria, emerged for the two current existing designs.

It was concluded that further study is needed and will be focused into the improvements of the overall tug design for operation in waves and in particular for specific equipment l fenders and winches. In the meantime the issue of winches has been addressed and resulted in requirements for winches if facing operations in exposed conditions. A second issue addressed was the ultimate stability to ascertain operators and tug captains that assisting in waves can be done safe. Surprising r learned were that a good tug design has a lot of inherent safety if some straightforward design decisions are taken.

The current SAFETUG project is almost nearing its completion, some time is needed now to digest the vast amount of results and its subsequent need for criteria (on winches, tug motions, deck safety, tug design, etc). In particular the wish to extend the project into more knowledge on the way to improve the tug designs for operation at sea is paramount.

Current tug development projects

Further actual specific projects within Marin are aimed at various aspects of tug design such as free sailing speed optimisation, bollard pull determination, bulbous bow design to decrease wash hindrance, course stability (ahead and astern) and the design of a compact tug. A recent development focuses on the set-up of a tug allocation programme which assists port operators with the tug assist requirements as a function of ship type, weather circumstances and other relevant aspects.

On the operations side, tug master training is becoming more and more a standard quality requirement in particular in relation to the ever increasing value/risk port management systems. Marin has to this end developed a COMPACT© manoeuvring simulator, which allows the use of simulation at low costs and superb quality on the tug modeling level. Port specific training sessions are given related to high risk environments.

ABOUT THE ORGANISATION

MARIN, the Maritime Research Institute Netherlands, has become a reliable, independent and innovative service provider for the maritime sector and a contributor to the well being of society. By maintaining their leadership position in hydrodynamic and nautical research and development, their accumulated know-how and experience is available for Concept Development, Design Support, Operations Support and Tool Development. Marin has a dual mission: to provide industry with innovative design solutions; and to carry out advanced research for the benefit of the maritime sector as a whole. In this way, they strengthen the link between academic research and market needs.

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